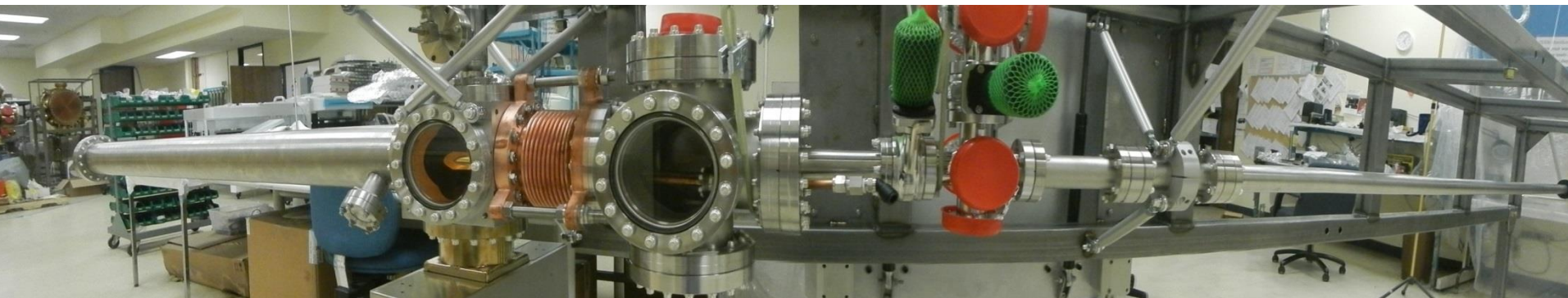


# CeC photo-injector

Presented to the  
**Machine Advisory Committee**  
By  
**John Skaritka**

With contributions from Erdong Wang and Brian Sheehy

December 8, 2014



# Talk outline

System overview

Cathode Stalk

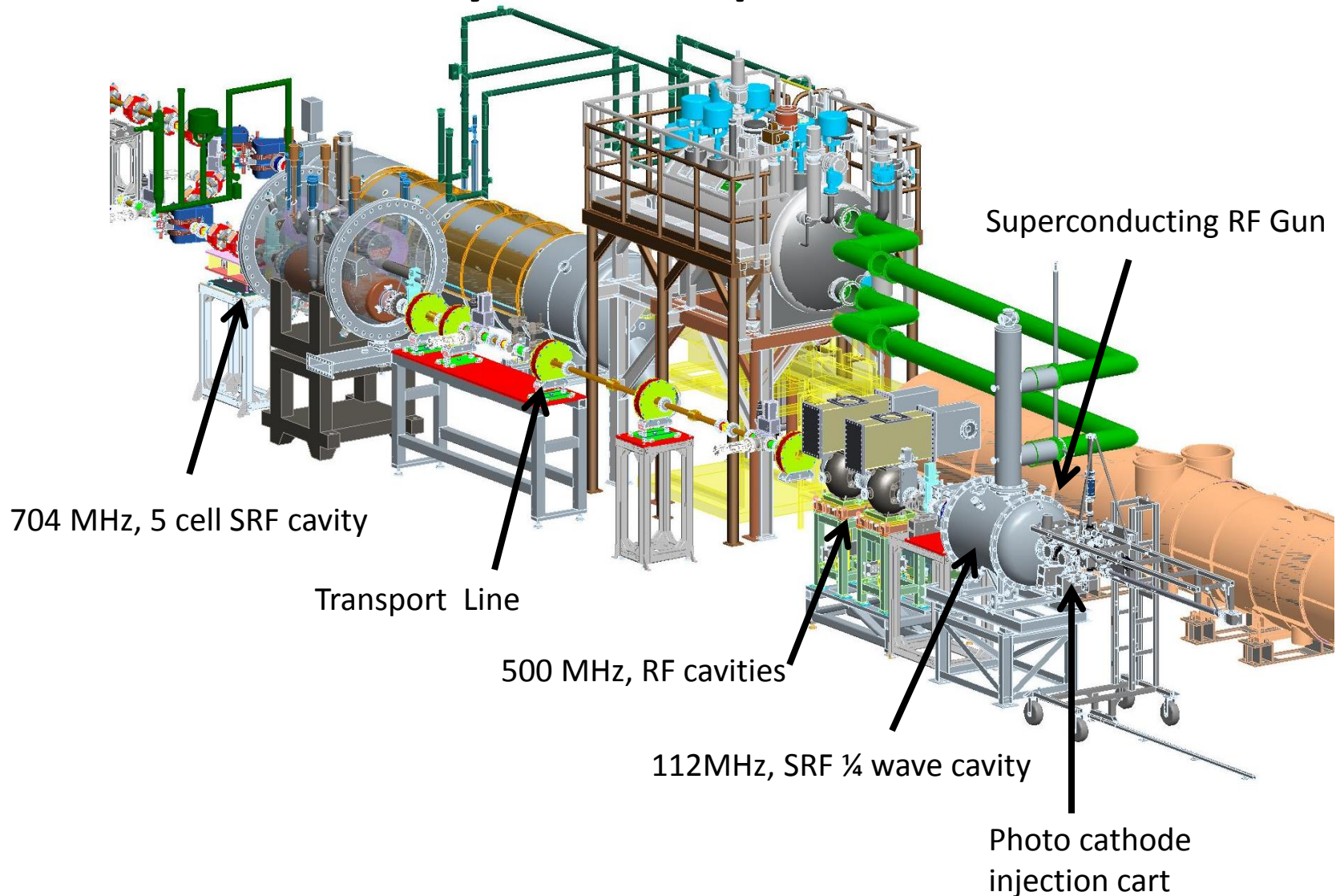
Cathode preparation

Laser system description

Cathode installation system

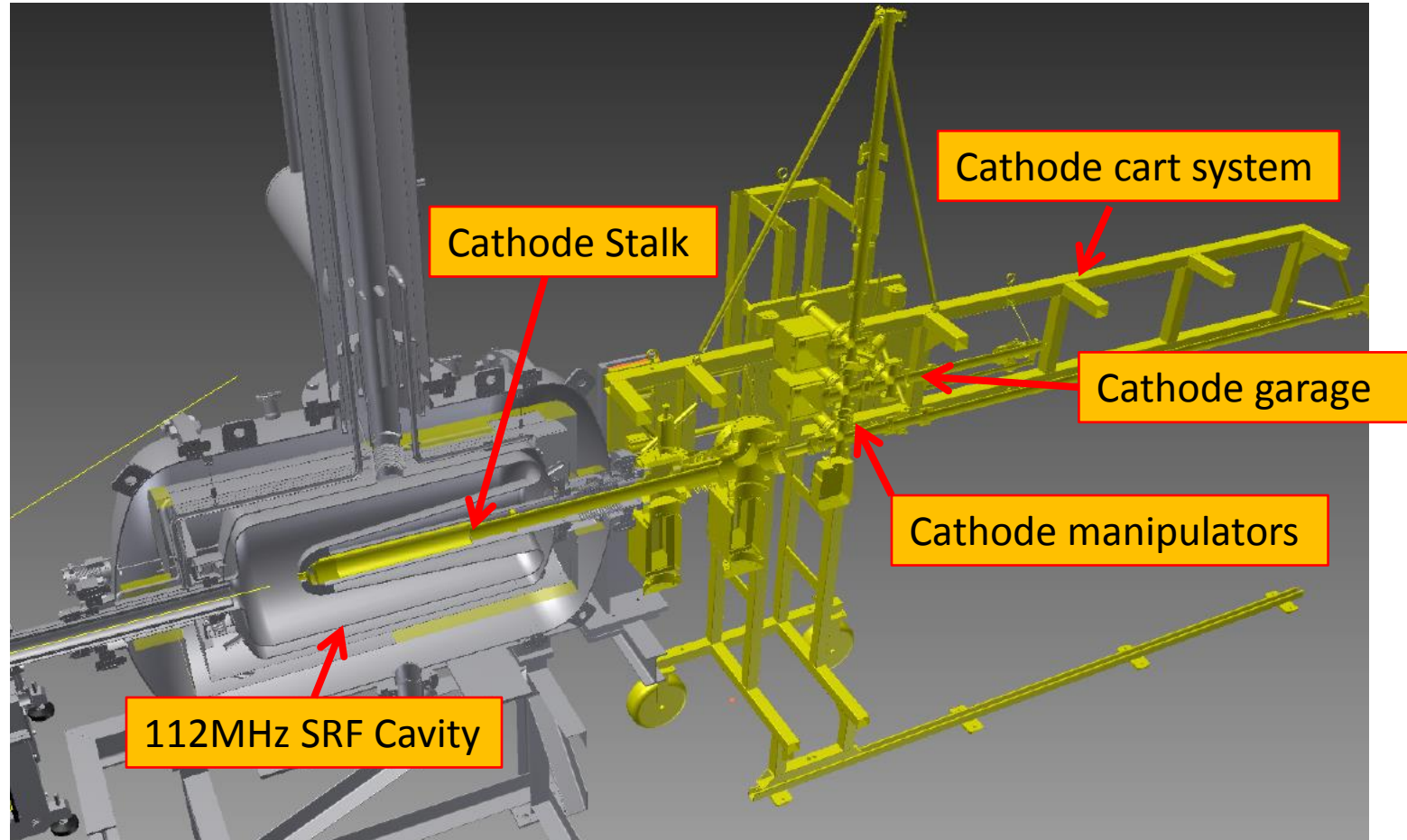
System Status and Summary

# CeC SRF system components



Coherent electron *Cooling* PoP

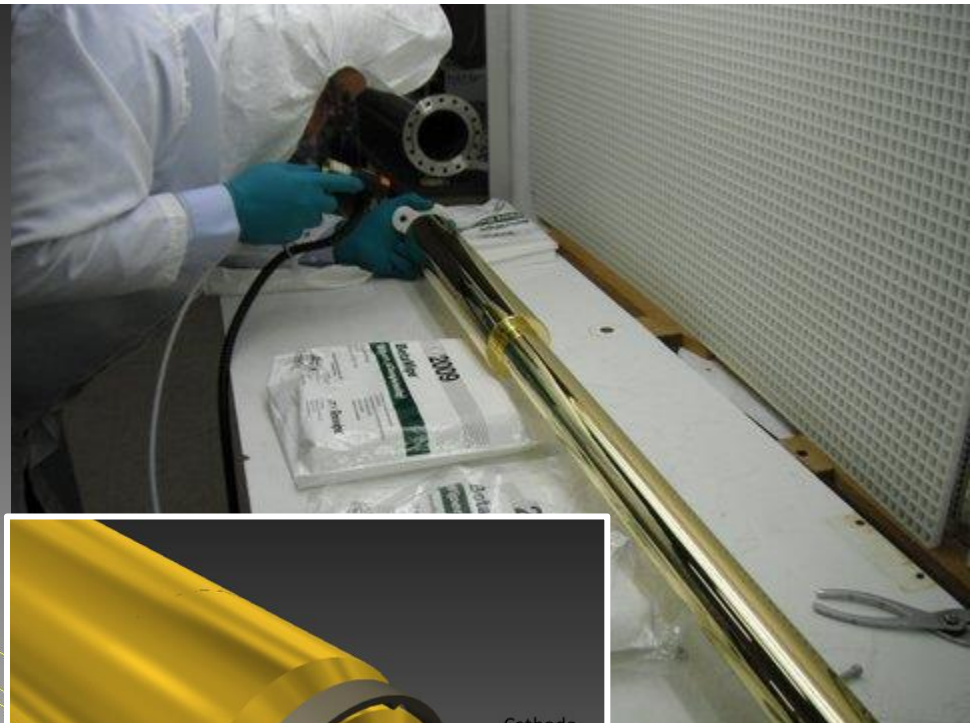
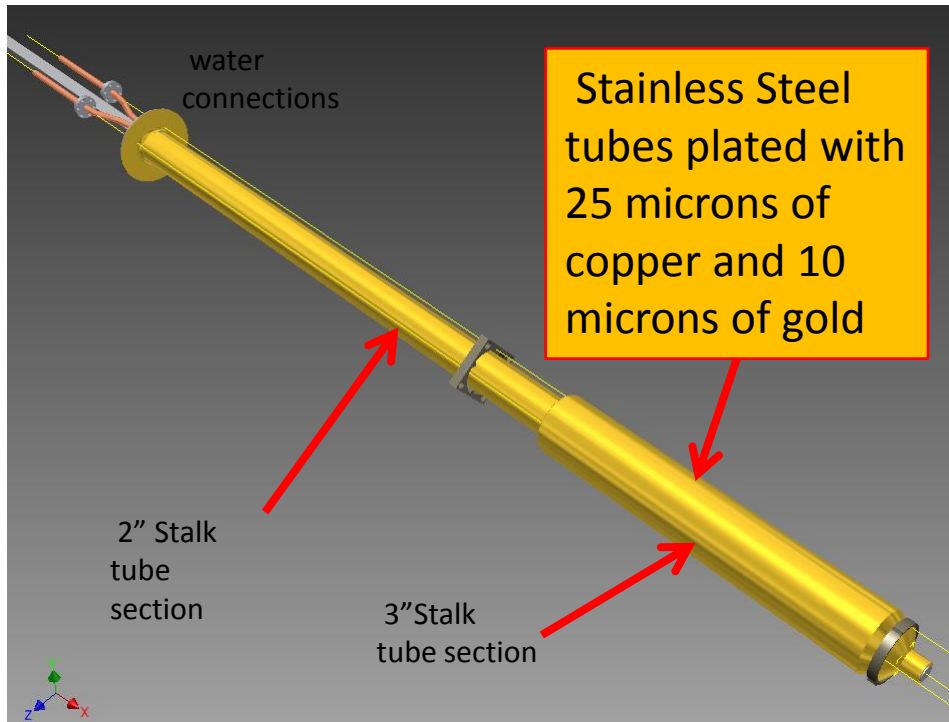
# Section View CeC SRF Gun



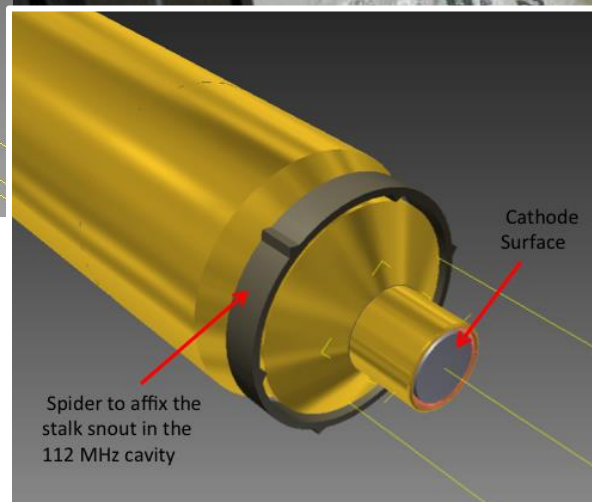
Coherent electron *Cooling* PoP

# Cathode stalk

- The cathode stalk is a hollow center conductor forming a coaxial line by the stalk and the cavity.
- The gold plating reduces radiation heat load from the RT stalk to the cold (4.5 K) niobium.



A cathode puck is inserted inside the stalk and can be replaced when necessary with a new puck.



Coherent electron Cooling PoP

**Vacuum manipulator and suite case attached to the Multi-alkali cathode preparation system at BNL's instrumentation division that deposits Cs, K, and Sb onto the cathode surface onto front face of the Molybdenum pucks.**



**Coherent electron *Cooling* PoP**

# CsK<sub>2</sub>Sb cathode preparation for 112MHz gun

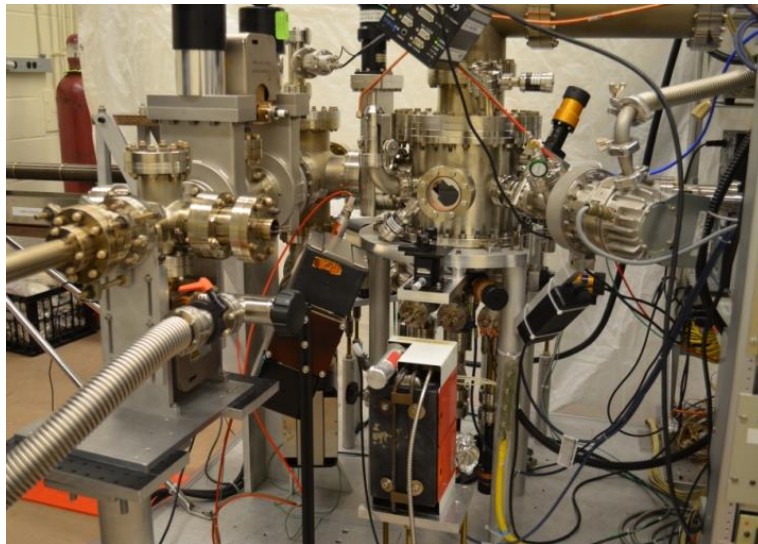
Quantum efficiency > 1% is requested for CeC PoP experiments

Two cathodes have been prepared to prepare 112MHz gun tests.

Quantum efficiencies for First one: 8.2%. Second one: 10.1%

Cathodes have good uniformity and surface finish.

Both preparation chamber and Cathode storage chamber has  $10^{-11}$  torr scale vacuum. The cathode QE lifetime is several months.



# Cathode surface deposition recipe

Heat up the stalk to 350° C for 6 hours.

Reduce the temperature to 90° C

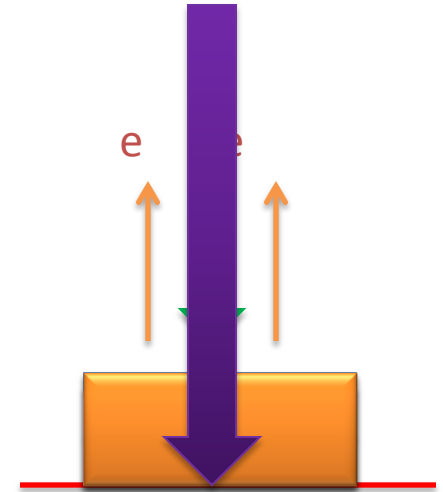
Evaporate Sb layer to 10 nm of thickness.

Increase the substrate temperature to 130° C.

Evaporate the K layer to 20nm .

Gradually reduce the temperature while evaporating Cs.

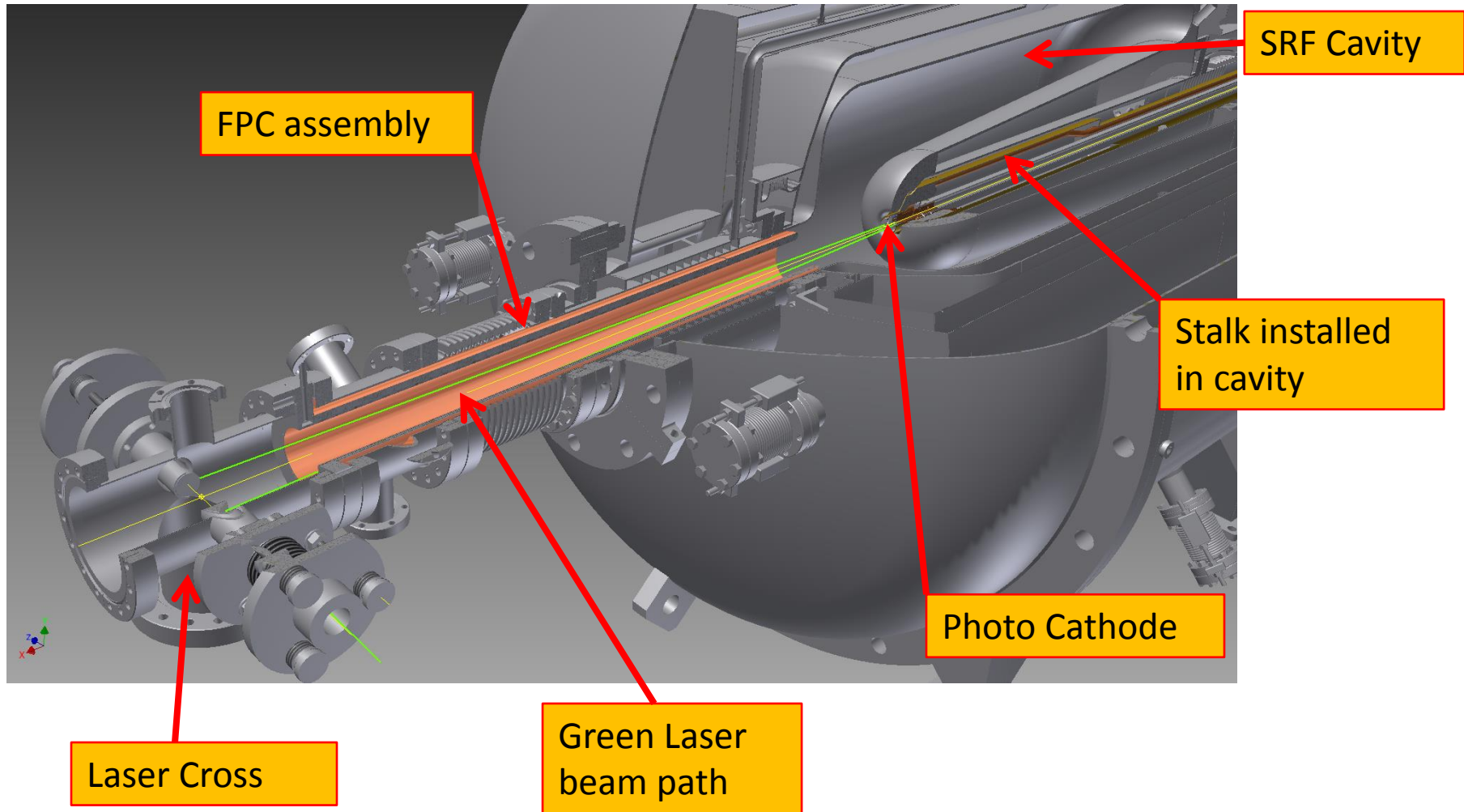
Fine tuning the Cs evaporate rate until the maximum photocurrent is obtained.



# Recent Improvements

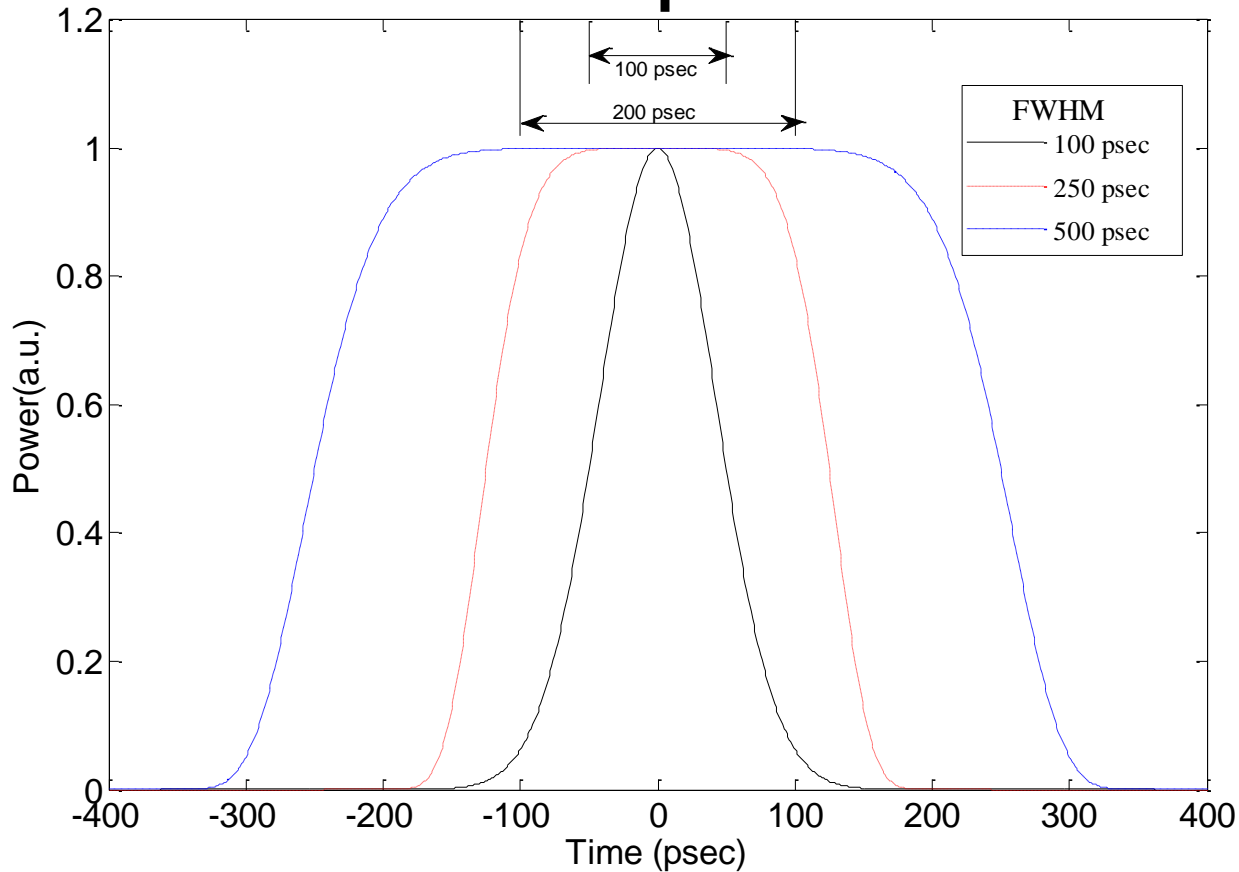
- We optimized our own cathode preparation recipe.
- Cathode substrate can be heated to 350° C before grow cathode.
- New Saes getter alkali sources are used in our cathode preparation. This allows us to fine tune the evaporation rate.
- Nano-meter polished substrate gives better cathode surface quality
- 8% to 11% QE of cathode are obtained routinely and reproducible.
- Additional cathode pucks are being prepared to assure an ample supply will be available for experimental operations.

# Section view of the Laser Path for the CeC SRF Gun



Coherent electron *Cooling* PoP

# Laser Requirements



- Objective is a flat pulse lasting 100-200 psec, in the green
- ~100 psec Gaussian should be achievable (70 psec 10%-90% rise)
- should be able to shape longer pulses
- Use central flat portion for cooling, electrons in the pulse wings are tolerable
- 1 kW peak power (100 nJ in 100 psec; 1 nC @ 2.3% QE with no losses)

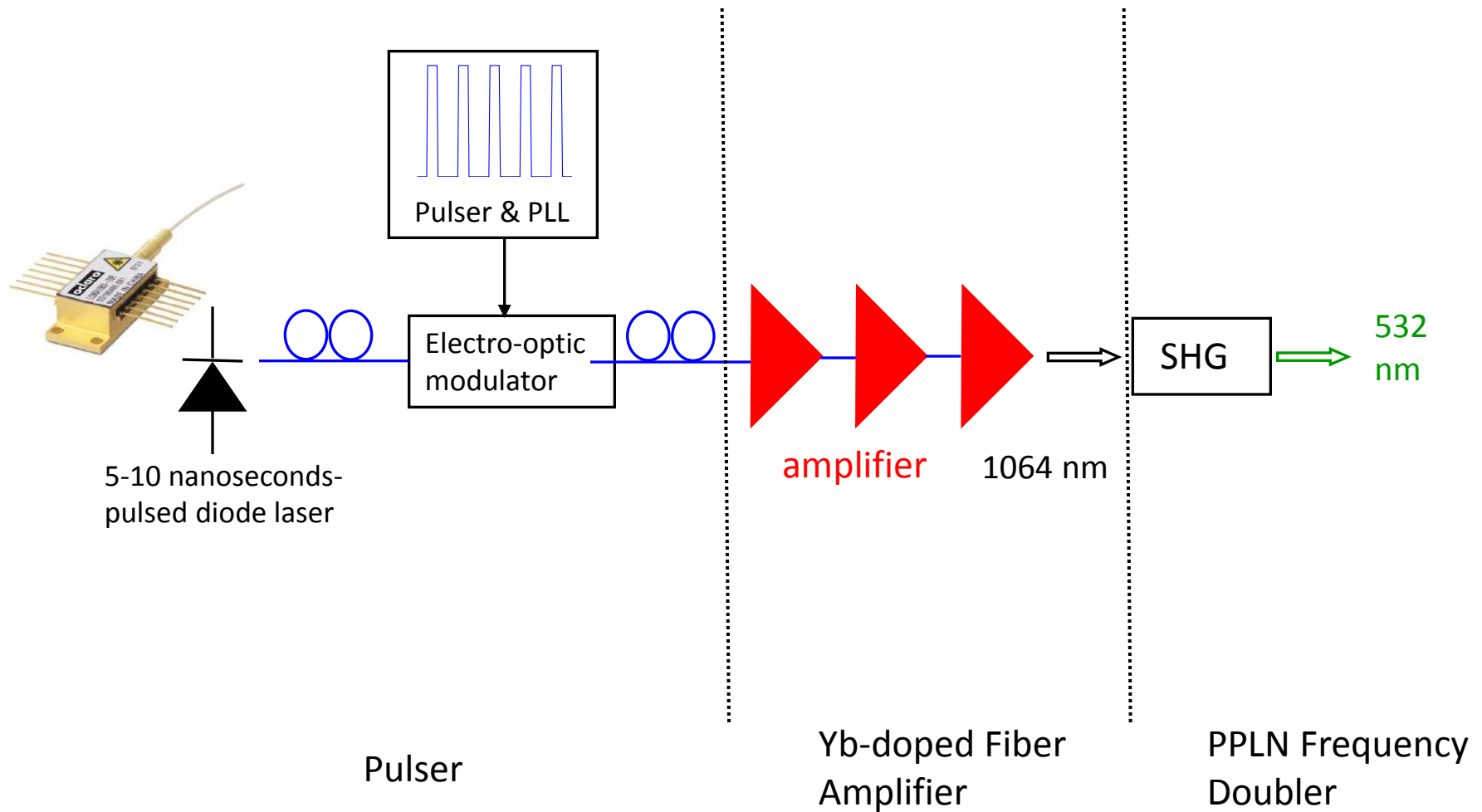
# Laser Requirements

Parameter	Unit	Value	
		Requirement	Selected*
Center wavelength $\lambda$	$\mu\text{m}$	$0.3 \leq \lambda \leq 0.532$	532
Center wavelength stability (24 hour)	nm	$\leq 1$	$< 0.1$
Bandwidth	nm	$\leq 10$	$< 0.1$
Repetition rate	kHz	$78.2 \pm 0.5$	
Peak Power	kW	$\geq 1$	
Average power	mW	8-40	
Pulse width	psec	100-500	
Pulse rise time	psec	$< 100$	
Pulse fall time	psec	$< 150$	
Plateau flatness		$\pm 9\%$	
Plateau width parameter		$a > 0.8$	
Jitter relative to trigger clock	psec	$\leq 10$	

Parameter	Unit	Value
Pulse amplitude stability (5 minutes)		$\leq 2\%$
amplitude drift		$\leq \pm 5\%$
Pulse contrast		$\leq 1e-6$
Polarization extinction	dB	20
Transverse mode beam quality factor	$M^2$	$\leq 1.3$

\* if different than Requirement

# Laser Block Diagram



Coherent electron *Cooling* PoP

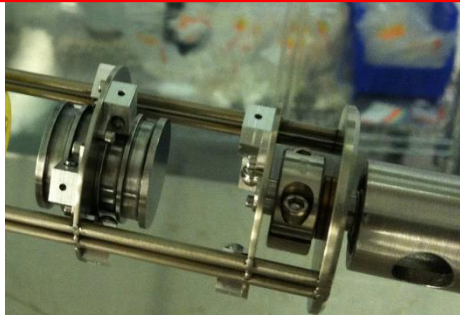
# Laser Schedule

- Laser has been delivered and tested in ERL laser facility in bldg 912
- Laser building at 2 o'clock is near ready for laser installation
  - Still some electrical and cable-pulling work to be done
- Transport fiber to be delivered in December 2014
  - conduit is already in place
- Breadboard and optical cross are installed; a small q-switched laser is available for preliminary beam tests.

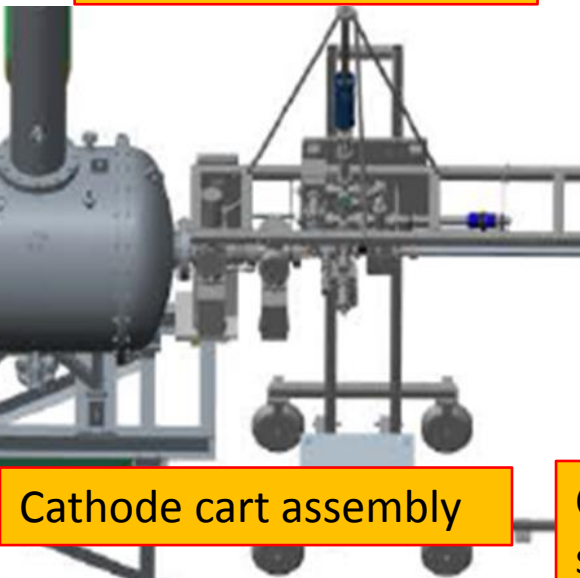
View of cathode cart at  
it's manufacturer  
Transfer Engineering and  
Manufacturing Company



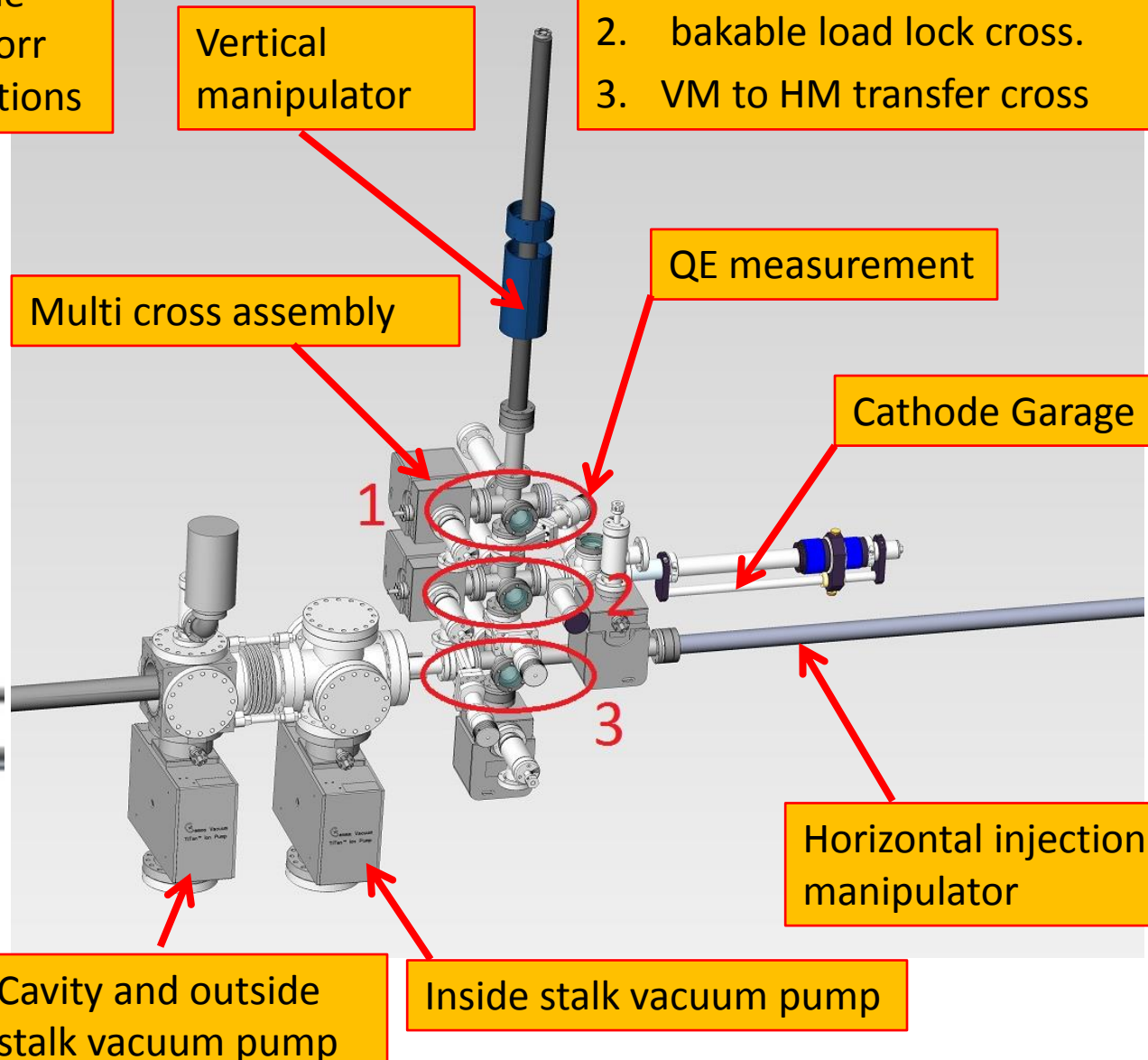
System has pumping to allow cathodes to pass through the system in vacuum of  $10^{-10}$  Torr range with  $< 1$  decade variations



Cathodes at end of Garage manipulator



Cathode cart assembly



Vertical manipulator

Multi cross assembly

1. On board QE diagnostic cross
2. bakable load lock cross.
3. VM to HM transfer cross

QE measurement

Cathode Garage

Horizontal injection manipulator

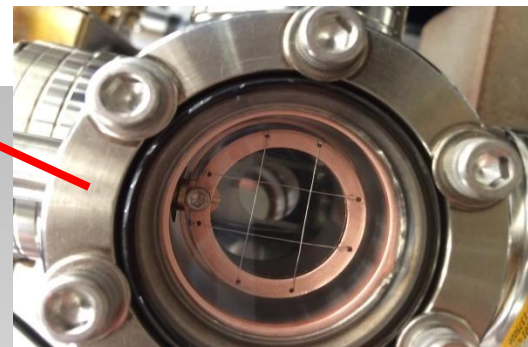
Cavity and outside stalk vacuum pump

Inside stalk vacuum pump

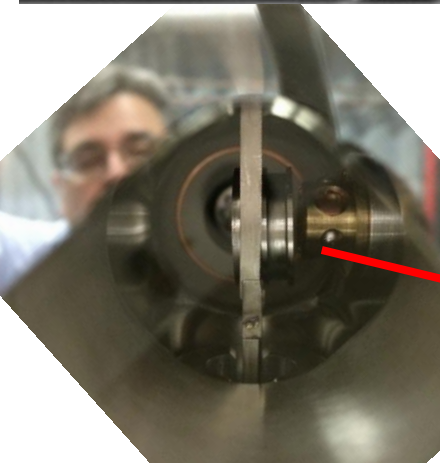
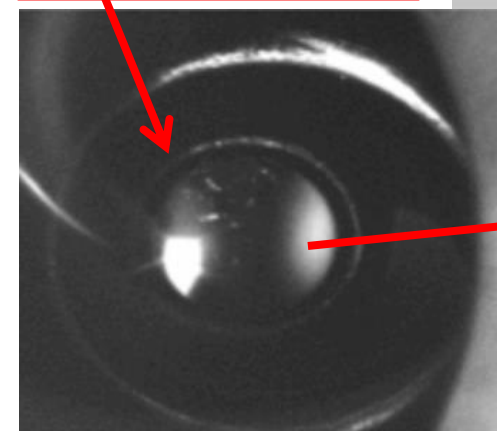
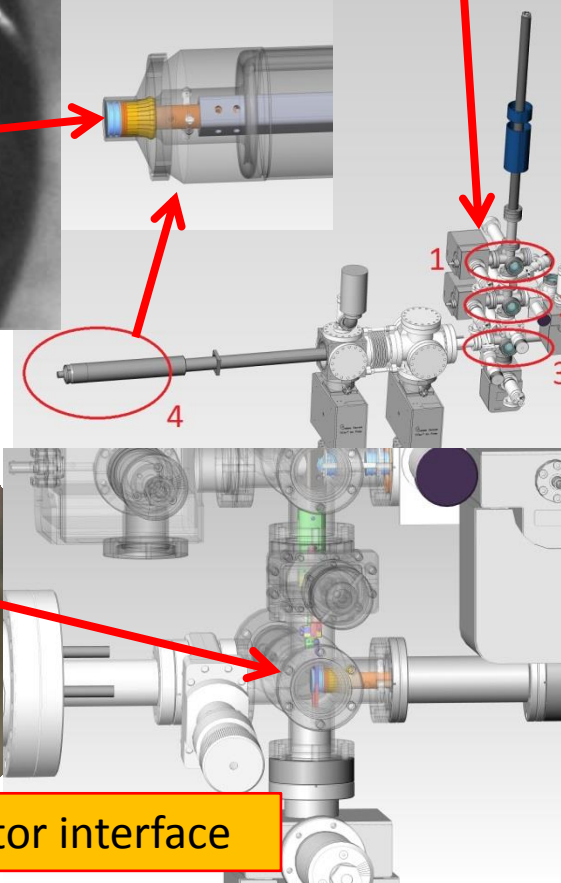
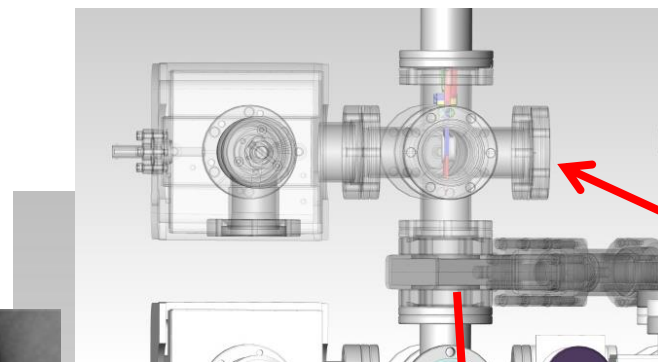
## Coherent electron *Cooling* PoP

Cathode puck in  
the SRF cavity  
SRF Gun

QE Diagnostic



Views of garage manipulator



Cathode to end effector interface

Coherent electron *Cooling* PoP

# Summary

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There have been significant improvements in the quantum efficiency of multi-Alkaline cathodes produced at BNL .

The stalk and cathode cart system was installed and was successfully used to install a cathode puck into the SRF cavity during the recent series of SRF cavity testing and conditioning.

The cathode cart system commissioning is underway to assure cathodes with robust quantum efficiencies are reliably transferred from the cathode garage to the end of the stalk and back again.

We are planning the SRF gun of the CeC PoP photo-injector system will begin operation during Run 15.